CPS 296.2: Advanced Topics in Computer Science

Mesh Generation

Syllabus

Basic Info

- **Course number:** CompSci 296.2
- **Semester:** Fall 2002
- **Schedule:** MW 10:20-11:35am (sug.)
- **Location:** LSRC D243
- **Instructor:** Alper Üngör
  D105 LSRC
  ungor@cs.duke.edu
  `http://www.cs.duke.edu/~ungor`
- **Office hours:** Mondays 3:30-4:30pm at the Bryan Center Café
- **Web-page:** `http://www.cs.duke.edu/courses/fall02/cps296.2`
- **Duke catalog number:** 3189
- **Section:** 2
- **Semester hours:** 3

Main Theme

Mesh generation finds numerous applications in scientific computing, computer graphics, solid modeling, computer aided design, geographic information systems, and medical imaging. In modeling the problems in these applications, the domains are partitioned into meshes consisting of small and simple elements (e.g. triangles, quadrilaterals, tetrahedra and hexahedra). Design and analysis of unstructured mesh generation algorithms will be the main theme in this course. Topics will include

Delaunay triangulations
Acute and nonobtuse triangulations
Element quality measures
Quadrilateral and hexahedral meshing
Delaunay refinement methods
Surface simplification
Smoothing and optimization
Parallel mesh generation
Advancing front methods
Adaptivity
Sphere-packing based methods
Space-time meshing

Course Material

- **Textbook:** *Geometry and Topology for Mesh Generation* by Herbert Edelsbrunner (Cambridge University Press, 2001).
- **Other books:**
  1. *Computational Geometry: Algorithms and Applications* by Mark de Berg, Marc van Kreveld, Mark Overmars, and Otfried Schwarzkopf (Springer-Verlag, 2nd edition, 2000).
  2. *Delaunay Triangulation and Meshing* by Paul-Louis George and Houman Borouchaki, (Editions Hermes, Paris, 1998).
  3. *Introduction to Algorithms (2nd ed)* by Thomas H.Cormen, Charles E. Leiserson, Ronald L. Rivest, and Cliff Stein, (MIT Press and McGraw-Hill, 2001)
- **Surveys:**
  1. "Mesh generation and optimal triangulation" by M. Bern and D. Eppstein in *Computing and Euclidean Geometry*, D.-Z. Du and F.K. Hwang, eds., World Scientific 1992.
  2. "Mesh Generation" by M. Bern and P. Plassmann in *Handbook of Computational Geometry*, J. Sack and J. Urrutia, eds., Elsevier Science, 1998
  3. "Triangulations and meshes in computational geometry" by H. Edelsbrunner, Acta Numerica, pp. 133-213, 2000.
  4. "Unstructured mesh generation: Theory, practice, and perspectives" by S.-H. Teng and C. W. Wong, *Int. J. Computational Geometry & Applications*, 10:3, pp 227-266, 2000.

Also watch the class web page for other papers, links, etc.

Coursework

Grades will be based on homeworks and a semester project. There will be no exams.

- **Homework:** There will be a written homework assignment every two weeks. Each will consists of two to three geometric problems.
- **Project:** It could be a survey paper, a programming project, or a research on an open problem. A half-page project proposal should be submitted by mid-semester. Project reports are due to the second last week of the semester. Each student will make at least one presentation in class. Each presentation take anywhere from 40 minutes to full class time depending on the material.

Tentative Timeline

Date	Lecture Topic	Assignments
Aug 26 M	Syllabus, course structure, etc.	HW#0 out
Aug 28 W	Triangulations	
Sep 2 M	Delaunay triangulations	HW#1 out
Sep 4 W	Element quality measures	
Sep 9 M	Delaunay refinement methods	HW#1 due
Sep 11 W	Quad-tree based methods	
Sep 16 M	Int. Meshing Roundtable, Ithaca NY (no class)	HW#2 out
Sep 18 W		
Sep 23 M	Sphere packings	HW#2 due
Sep 25 W	Medial axis	
Sep 30 M	Quadrilateral and hexahedral meshing	HW#3 out
Oct 2 W	Advancing front methods	
Oct 7 M	Smoothing and optimization	HW#3 due
Oct 9 W	Acute and nonobtuse triangulations	Project proposal due
Oct 14 M	Fall Break (no class)	
Oct 16 W	Refinement and coarsening	HW#4 out
Oct 21 M	Parallel mesh generation	
Oct 23 W	Sliver removal	HW#4 due
Oct 28 M	Space-time meshing	
Oct 30 W	Surface reconstruction	HW#5 out
Nov 4 M	Surface simplification	
Nov 6 W	Project presentation	HW#5 due
Nov 11 M	Project presentation	
Nov 13 W	Project presentation	
Nov 18 M	Conference travel (guest lecturer or no class)	
Nov 20 W		
Nov 25 M	Project presentation	Project report due
Nov 27 W	Project presentation	